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# PROCEEDINGS

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# DISCUSSION OF PROCEEDINGS - SEPARATES

130, 208, 231

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## DISCUSSION OF UNDERGROUND CORROSION OF PIPING
## PROCEEDINGS-SEPARATE NO. 130

LYLE R. SHEPPARD.[4]—The subject of this paper is covered very well by Mr. Brannon. However, the writer would further stress the importance of utilizing the experiences of others in corrosion mitigation because it has become such a specialized field.

Also, it is felt that the author should present some of the reasons for the greater interest in underground corrosion of pipes. Among these reasons are the following representing conditions existing in 1952:

1. A greater variety and larger volumes of products are being transported by pipe lines;
2. The increased operating pressure used in pipe lines constitutes a greater hazard;
3. Deeper burial in unleached (and thus more corrosive) soils to minimize partly safety hazards has become the practice;
4. The need for continued pipe line service has increased because of the dependence on them, rather than on other means of transportation;
5. The percentage of oil storage volume in service has decreased in comparison with the volume transported by pipe lines, more oil going immediately into process;
6. There is a trend toward the use of thinner pipe to conserve steel and to decrease construction and investment costs;
7. The value of the transported products has increased;
8. The property damage due to leaks has become more costly; and
9. The costs of pipe line replacements, both in materials and labor, have increased.

R. A. BRANNON.[5]—The author agrees that the additions suggested by Mr. Sheppard are appropriate. Although each of the items he lists could be discussed at greater length, it is believed that the mention Mr. Sheppard has made of them is sufficient to indicate the reasons for the greater interests in underground corrosion of pipes.

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DISCUSSION OF
THE KEY WEST AQUEDUCT
PROCEEDINGS—SEPARATE NO. 208

H. Alden Foster, M. ASCE,[1] and James Hannan, Jr.[2] This paper provides an excellent history of the Key West Aqueduct covering preliminary developments, design, construction, operation during the past eleven years and possible future changes. The present writers submit the following comments for the purpose of making the record more complete.

As stated by the authors, the Florida Keys Aqueduct Commission was created by the Florida State Legislature in 1937 with powers to investigate the possibility of furnishing a fresh water supply to the civilian residents of the Keys and the City of Key West. The Commission engaged the services of Elson T. Killam, Member ASCE, as consulting engineer, who prepared an extensive report covering in considerable detail the possibilities of a water supply for the areas in question. This report recommended developing a supply on the mainland of Florida as near the Keys as possible, and transporting the fresh water to Key West by means of a pipeline with provisions for supplying small distribution systems on the more populous Keys. Due to difficulties of financing such a project, the Commission was unable to put this plan into effect.

In 1940, when the U.S. Navy Department found it necessary to provide a dependable fresh water supply for its Naval Station at Key West, they engaged the consulting engineering firm of Parsons, Klapp, Brinckerhoff and Douglas (now Parsons, Brinckerhoff, Hall and Macdonald) to prepare an independent report on this project as related to Navy requirements. The consulting engineers made an investigation of the relative advantages and disadvantages of providing this supply by means of a pipeline from the mainland or by evaporation of sea water at Key West. The studies indicated that, considering all costs over a long term period, a pipeline would be more economical. The engineers' report, submitted in December 1940, recommended construction of a 12-inch diameter pipe to serve only the needs of the Navy.

As explained by the authors of the paper, the Aqueduct Commission entered the picture again, and eventually the Navy's consulting engineers were commissioned to prepare detailed plans and specifications for construction of a pumping station and pipeline with a total capacity of 3 million gallons per day to serve the combined needs of the Navy and the Commission.

Field parties were promptly sent out,—one group to make the necessary surveys and coordinate existing data covering the 128 miles to be traversed by the pipeline, and another group to secure the necessary data regarding availability of fresh water. The latter group investigated an area southwest of Florida City, which is the southernmost populated community on the Florida mainland. This area was on the fringe of the pine land and glade land, the plan being to stay on the higher pine land if possible. The elevation of this pine land is about 8.0 feet above sea level, or in rare instances up to 10.0 feet. Numerous test holes were drilled to determine the ground water level.

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2. Member, Amer. Water Works Assoc.; Chief Engineer, Intercounty Construction Corp., Hyattsville, Md.

Existing holes, previously used by the U.S. Geological Survey, were reopened. Observation stations were established in borrow pits and along the numerous canals. Daily records of ground water elevations, rainfall and chloride content of the ground water were kept. Observations were also carried out on the wells of the nearby City of Homestead through the cooperation of the Water Department of that town;—this being the nearest water supply to that proposed for the Navy.

The investigations showed that a large underground fresh water supply existed with the best water being obtained at a depth of from 50 to 60 feet below ground surface and flowing generally from northwest to southeast. The elevation of the ground water surface varied considerably and with a very short time lag in accordance with general rainfall, but was only slightly affected by the numerous localized heavy showers. Care had to be taken to select a site which would not be affected by salt water intrusion following along drainage canals which extend a long distance inland. Due to a large farming area being located between the site selected for the wells and the ocean, most of the canals in this area had artificial dams constructed near their outlets with sufficient pumping equipment to care for fresh water flooding, so that the salt water was prevented from encroaching.

The site purchased by the Navy consisted of 375 acres for a well-field and pumping station. A test well installed at this location showed satisfactory results. It may be of interest to mention that the water table in this area is normally at or above sea level, frequently only four or five feet from the surface. There are numerous fire hydrants without any distribution system which are able to supply 500 gpm. pumping engines by the simple expedient of driving 10 feet of pipe into the ground with a Tee and 4-1/2 inch threaded suction connection.

The work of the survey parties assigned to the pipeline location was considerably speeded by the use of the R. O. W. maps of the Florida East Coast Railroad, which furnished a continuous survey base line from Homestead to Key West. The State Road Department was also completing surveys in connection with the proposed Overseas Highway to be built on the old railroad R.O.W.[3] These surveys enabled the pipeline to be located so as to interfere as little as possible with the proposed road construction; but the necessity of keeping the pipe adjacent to a road that was not yet constructed and which would be chiefly in fill complicated the problem considerably.

In general, where the old railroad was on fill, the pipeline was located in original ground at the bottom of slope of the fill. Where the railroad was supported by multiple concrete arches of 25-50 ft. span, the highway deck had been constructed by placing transverse beams on top of the existing spandrel walls. The pipeline was placed underneath the overhanging roadway on brackets securely bolted through the spandrel wall.

Where the highway was supported by steel plate girder spans, the pipeline was located under the overhanging deck, supported by steel brackets welded to the girders. At the Bahia-Honda Bridge, which consists of steel trusses, the roadway is located on the top chord of the trusses in order to obtain sufficient width. This left the through deck formerly occupied by the railroad track available for the pipeline, which is supported by the existing floorbeams.

In order to reduce as much as possible the risk of damage to the pipeline by hurricanes, it was located on the Gulf side of the Keys and bridges wherever

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3. See Engineering News-Record, June 15, 1944, Page 94.

possible. Apparently, similar considerations had been applied by the American Telephone and Telegraph Co. whose lines and cables were located on the Gulf side along the railroad R. O. W. and on most of the bridges within the Toll District. Unfortunately, due to the nature of their construction, it was not possible to develop a satisfactory plan for the pipeline to be installed on the same side of the bridges as the A. T. and T. Co. plant, so that in several places a more exposed location had to be accepted.

In the 1935 hurricane a substantial part of the railroad fill was washed away. It was felt that in the event of a repetition of such a storm it would be advantageous to bury the pipe in exposed reaches. Since the top surface of the Key is relatively hard and forms a shell which has, in fact, been responsible for the Keys remaining through many storms, a pipeline in a trench below this hard surface layer represented the most advantageous location through exposed areas where the pipe was not securely anchored to bridges.

Much valuable advice relative to location of the pipeline was given by B. M. Duncan, Chief Engineer of the Overseas Road and Toll Bridge District.

Since practically the entire pumping head (approximately 900 ft. at full load) is due to pipe friction, the coefficient of friction of the pipe assumes great importance. For this reason, bituminous enamel lining was specified for the pipe.

In order to avoid formation of long air pockets in the pipe during operation, the line was definitely graded to create artificial high and low points. Automatic air release valves were provided at all high points and blow-offs at all low points. All air valves, except those on the bridges, were provided with concrete chambers, as were all gate valves installed along the line. Provision for observing flow conditions was made by the installation of recording pressure gauges and venturi meters with recorders. One set of recording pressure gauges and meters was installed at the pumping station, and similar sets at Upper Matecumbe Key, approximately 48 miles from the pumping station, and at Big Pine Key, approximately 50 miles farther south. All distribution connections in Key West were to be metered. Tees and gate valves were provided at numerous places along the line for connections by the Aqueduct Commission.

Every air valve and blow-off was found to be vitally essential when filling the line with potable water for the first time, as the entire operation had to be carried on from the Homestead end. The fact that the line was graded was of material assistance, but it still took ten days of continuous 24-hour closely co-ordinated work to get water from Homestead to Key West.

Although supervision of construction was entirely in the hands of the Navy, the Consulting Engineers were called in to design anchorages for certain bends where structural weakness developed during the testing period. As explained by the authors, it was necessary to put the pipeline in temporary operation at partial load before it had been tested at the specified pressure of 450 lbs. per sq. in. The original intention was to anchor the bends by encasing them in concrete blocks poured directly against the sides of the trench, where the latter was located in firm ground. In some cases, sufficient anchorage of this type had not been installed. In other cases, the ground did not have sufficient strength to take the pipe thrust. A number of these unanchored bends failed under the pressure test. Most of the anchors provided to correct this condition were designed to take the pipe thrust by batter piles.

James Hannan, Jr. was in charge of design of the pipeline for Parsons, Klapp, Brinckerhoff and Douglas, and also assisted the inspection staff of the Navy during construction. H. Alden Foster reviewed the hydraulics of the

pipeline, particularly as related to water hammer effects, and made studies for the field-designed anchorages noted above. Elson T. Killam acted in a consulting capacity during the detailed design. In all the investigations relative to available supplies of fresh water, the engineers of the U.S. Geological Survey, who were engaged in making a survey of potential sources of supply in Florida, were very cooperative.

## DISCUSSION OF
## ANALYSIS OF WATER QUALITY CRITERIA
## PROCEEDINGS—SEPARATE NO. 231

Edward J. Cleary, M. ASCE.—The philosophy set forth by Dr. McKee and Mr. Bacon (Separate No. 231, vol. 79, Proceedings, August 1953) commands the attention of sanitary engineers who seek to practice rationality in stream-pollution control rather than succumb to the lure of so-called administrative expediencies. In their paper on the analysis of water-quality criteria the authors have written an excellent prelude for an appreciation of the concept of case-by-case determination of control regulation.

Unfortunately, the authors emphasis on stream standards versus effluent standards may obscure the fact that quality-criteria evaluation is really only one element of the technique of pollution-control technique. In other words, the paper is confined to only part of a basic theory of pollution control, the application of which needs considerable explanation in order to appreciate its virtues. It would have been valuable, therefore, had the authors outlined the additional steps that must be taken in order to complete the examination of a situation and thereby show how engineering analysis, economic appraisal and equity relationships are applied in reaching a conclusion.

Application of these procedures has found expression in the Ohio River pollution control program for the establishment of municipal sewage-treatment requirements, and they are now being tested for application in the eminently more complex business of industrial waste regulation.

Requirements for municipal sewage discharged into the Ohio River were drafted only after a case-by-case examination of pollution loads, the relationship of these loads to the assimilative capacity of the stream and then the determination of treatment necessities to secure desired water quality criteria. Thus the treatment requirements for each municipality represented an individual determination to fit specified needs.

Following determination of treatment requirements at specific places it became apparent that similar requirements were applicable to river sections of various length and thus it became possible to create so-called zones in which uniform performance could be specified for a group of municipalities. Let me emphasize, however, that the length of these river sections and the requirements therein for sewage treatment followed after engineering analysis and economic appraisal and did not represent an arbitrary classification in advance of thorough and detailed investigation.

In their comments on the ORSANCO program I noted a possible confusion in the minds of the authors over the use of the term "standards" in the Ohio River program. Perhaps it is unfortunate that the phraseology in specifying performance for each municipality refers to "Standard No. 1, 2, etc." But the use of the term "standard" is simply the language used in the compact and is a legal title for what actually is an individualized determination and not the arbitrary application of a symbol and number, which is the usual connotation applied to the term standard.

In the drafting of industrial-waste requirements, on which ORSANCO is now working, a similar case-by-case consideration will be tested for application. In fact, the compact under which the eight states comprising the

ORSANCO organization operate contains a clause which can be interpreted to require nothing less than case-by-case examination. This clause in Article VI of the compact states: "All industrial waste shall be modified or treated, to such degree as may be determined to be necessary by the Commission after investigation, due notice and hearing." It is interesting to note that the compact was written some years before the California authorities enunciated their adoption of a policy of case-by-case determination.

## Principle and Application

Since the authors did not describe the various steps by which they propose to make case-by-case determinations it may be useful to detail briefly the principle and procedures by which this concept might be applied in drafting regulations.

In so doing I would enunciate the following as the basic principle on which a pollution control program should be based. It is this: A stream should be clean enough for the uses it is intended to serve; and, conversely, there is no economic justification for a stream to be cleaner than is suitable for its present and indicated uses. It is my belief that not until we have accepted the principle that stream cleanliness should be based on use requirements do we have the opportunity to develop a pollution-control program that is practicable, reasonable and rational. The fundamental principle, therefore, that I claim should underlie the conduct of pollution-control activities, might be stated in this fashion:

> Requirements for the modification or restriction of waste discharges into a stream shall be designed to safeguard and maintain water uses that will serve the public interest in the most beneficial manner.

The application of this principle in designing requirements on a specific stream or some portion of it might then be said to fall into three steps:

1. The first step is concerned with the determination of water uses.
2. The second deals with application of yardsticks of quality in defining suitability of water, namely, water-quality criteria, and
3. The third step involves the formulation of waste-control regulations in accordance with engineering, economic and equity relationships.

Looking at the matter in this fashion I conclude that the discussion by Dr. McKee and Mr. Bacon dealt, in fact, only with the second step. In other words, quite a bit more needs to be outlined before we can say that a complete procedure has been outlined for carrying out the theory of case-by-case examination. I refer specifically to the elements of determination of water use, which is Step 1, and to the third and final step, which is the integration of scientific knowledge, economic appraisal and equity reconciliation in the design of specific requirements that must be met by a polluter.

Step 1—Recognizing the limitation of space for this discussion I will say only this with regard to Step 1. You must first be concerned with weighing the relative importance of water uses in terms of the public interest. Not until such a determination has been made are you ready to be concerned with water-quality criteria. Generally speaking, determination of water uses should be

established on the basis of demonstrated needs as revealed from present uses or demanded by local conditions. And such an appraisal should include a cognizance of the variations and relative importance of established use-patterns in different stretches of the river.

Step 2—Having made the determination of stream uses we then face the question of defining suitability of water for the uses it is intended to serve. This is the matter to which Dr. McKee and Mr. Bacon addressed themselves. I feel, however, that much more needs to be said about the practical application of criteria. For example, they refer to the compendium of water-quality criteria which was developed for reference in the California work. Without denying the great value of this compendium I can conceive of it only as an assembly of the various symbols and numbers that have been employed in various places to measure water quality.

There still needs to be a decision made on what specific value should be chosen to serve as the yardstick for measuring suitability of water in terms of a particular use. For example, in the California compendium the section on phenol-threshold concentrations for taste and odors lists nine different values as used by various authorities. The question that must be resolved by the California pollution-control authorities—as well as any other regulatory agency—is which of these values should be used as the criterion to measure the suitability of water so far as taste and odor safeguards are concerned. In other words, some agreement must be reached on the use of a specific value. The compendium should not be considered—and I know it is not so considered by Dr. McKee and Mr. Bacon—as a substitute for judgment.

Step 3—Without going into the details of what I consider the most complex element in reaching the final conclusion as to what a polluter should do in order to safeguard the stream I would sum up this third and vital step as follows: Design of control regulations should reflect utilization of the assimilative capacity of the stream, incorporate an appraisal of benefits versus costs and represent an effort to reconcile equities. However, uniformity of policy in the design of pollution control regulations does not mean standardization of requirements or that the burdens of compliance will fall equally on all polluters. In other words, only until you have gone through the entire gamut of the three steps can it be said that you have made a case-by-case examination of a situation and are ready to defend your conclusion as being practicable, reasonable and rational.

## Rationality in Practice

Dr. McKee and Mr. Bacon have made a vital contribution to sanitary-engineering thinking in exposing what appear to be certain irrationalities in the administration and practice of pollution control. Their stimulating presentation should inspire a re-reading of the sound and provocative proposals made by Thomas R. Camp, M. Am. Soc. C. E. some years ago and which has been published as paper No. 2433 of the 1951 Transactions of the American Society of Civil Engineers, (also temporarily available as Separate No. 10, published in March, 1950). In this paper, titled "Pollution Abatement Policy", Mr. Camp espouses certain principles that are basic to the conduct of pollution-control activities.

While there may be some differences of opinion regarding Mr. Camp's proposal for the equitable assessment of cost, every other principle that he sets forth in this brilliant display of logic cannot be denied as being sound and practical.

To fully appreciate the merits of what Dr. McKee and Mr. Bacon set forth the reader should acquaint himself with the exposition of fundamentals so clearly enunciated by Mr. Camp.